

## Phys141 - Wed 9/20

- Today: Chapter 5.5-5.8
  - examples of Newtons laws
  - Friction

### Administrative:

For Fri: Read: Chapter 6.1,2

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## Free Body Diagram

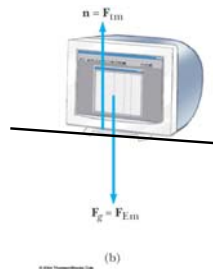
Chapter 5

- Free body diagram: forces acting on one particular object

### Example: forces acting on monitor on table

- Normal force (a contact force - the table pushing the monitor upward)
- force of gravity (earth pulling the monitor downward)

- NOTE: In addition, the normal force of the table/monitor contact is also a force acting ON THE TABLE




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- Apply equilibrium equation (Newton 2<sup>nd</sup> law) to the traffic light and find  $T_3$

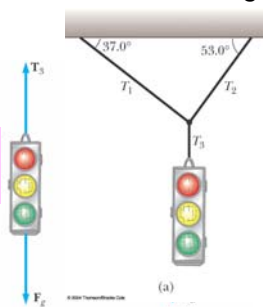
- Note: Object pulling a rope with a force: the magnitude of that force,  $T$ , is the tension in the rope

Use Newtons 3<sup>rd</sup> law: Traffic Light pulls on knot with same Magnitude and opposite direction of force as knot pulls on light

- Apply equilibrium equations to the knot and find  $T_1$  and  $T_2$

## Tension in strings

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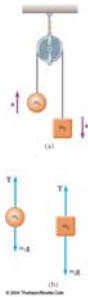
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## Accelerating objects

Chapter 5

- Forces acting on the objects:
  - Tension (same for both objects, one string)
  - Gravitational force
- Each object has the same acceleration since they are connected
- Draw the free-body diagrams
- Apply Newton's Laws
- Solve for the unknown(s)




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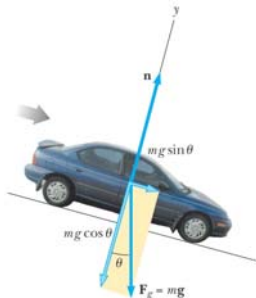
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## Object on inclined planes

Chapter 5

- Forces acting on the object:
  - Normal force,  $n$ ,  
Exerted by surface - perpendicular to the surface  
Equal in magnitude, opposite in direction to force exerted by car on surface
  - Gravitational force,  $F_g$  :  
Exerted by earth - toward earth center
- Choose the coordinate system with  $x$  along the incline and  $y$  perpendicular to the incline
- Replace the force of gravity with its components perpendicular and along the surface



Nonzero net force -> object accelerates

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## Forces of Friction

Chapter 5

- When an object is in motion on a surface or through a viscous medium, there will be a resistance to the motion
  - This is due to the interactions between the object and its environment
- This resistance is called the *force of friction*

Note: Friction Laws are still not fully understood - below are RULES of THUMB that work remarkably well in many situations

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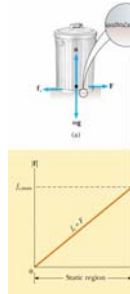
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## Static Friction

object does not move, pulled by force  $F$ , resisted by static friction

•  $f_s \leq \mu_s n$

- If  $F$  increases, so does  $f_s$
- If  $F$  decreases, so does  $f_s$
- equality only holds when the surfaces are on the verge of slipping




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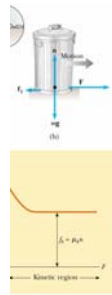
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## Kinetic Friction

friction when the object is in motion

$\mu_k$  can vary with speed in general (but not in this class)

$f_k = \mu_k n$




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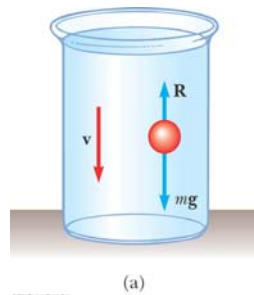
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## Friction in fluid: Viscous drag

Drag force  $R$  in viscous fluid proportional to velocity

$R = bv$   
(or  $R \sim v^2$  for turbulent fluids)

- At some speed, resistance equals gravitational force
- > no further acceleration
  - > this is maximum speed




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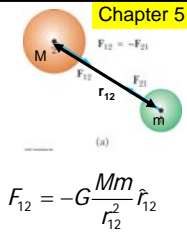
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## Gravitational Force $F_g$

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(see also Chapter 13.1)

- Force one object of mass  $M$  exerts on another object of mass  $m$
- Directed between the centers of the two objects
- Gravitational force determined by
  - mass of object.
    - Larger mass  $\rightarrow$  larger gravitational force
  - Mass of other object (e.g. earth)
    - Larger mass  $\rightarrow$  larger gravitational force
  - distance from center of that object
    - Shorter distance  $\rightarrow$  larger gravitational force




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## Gravitational force on earth

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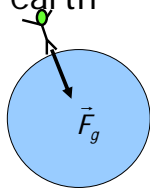
$$\vec{F}_g = -G \frac{Mm}{r_{12}^2} \hat{r}_{12}$$

On earth: our distance from center of earth pretty much always the same, and the mass of the earth is constant

$G \frac{M}{r_{12}^2}$  is roughly constant: It is called  $g$ , the gravitational constant  $9.8 \text{ m/s}^2$

$$\vec{F}_g = m\vec{g}$$

- Magnitude of gravitational force is called the weight of the object
  - Weight =  $|F_g| = mg$




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## Mass and weight are two different quantities

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Mass determines inertia and gravitational force

Weight is magnitude of the gravitational force and depends on Mass of other object which exerts a gravitational force, and distance from center of that other object

$\rightarrow$  On the moon, our Mass is the same, but our Weight is different!

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